# TOUCH INPUT DEVICE WITH DISPLAY FRONT

## FIELD OF THE INVENTION

[0001] The present invention relates to a touch sensitive device with an electronically addressable display front and systems including such devices.

## BACKGROUND OF THE INVENTION

[0002] Since their conception in the 1970's, touchscreen displays have grown into one of the most popular forms of user interface in the computing world. Kiosks, machine controllers, and personal digital assistants (PDAs), are just a few of the common devices that utilize this technology. Touchscreen simplicity combined with display adaptability can be made to serve the function of a keyboard, mouse, pen, number pad, and many other input devices, all combined into a single unit. Touchscreen display assemblies are typically formed by positioning a touch-sensing layer or field in front of the display relative to the user. Today there are four popular ways to make a display touch sensitive: Resistive, Capacitive, Ultrasonic, and Infrared.

[0003] The resistive style consists of two clear conductors spaced apart by physical dots. When the assembly is depressed, the conductors touch and detectors determine the touch location by measuring the currents in the x and y directions. This method is the least expensive and does not require a conductive stylus, but it suffers up to 25% of optical loss. Resistive touchscreens are typically manufactured independently of the final device for which they are used, as this is frequently the most cost effective manner for production. One way that this is accomplished is to coat two rolls or sheets of substrate material with a clear conductor, for example a sputter coated layer of Indium Tin Oxide (ITO), then screen print spacers and sensing electronics, and laminate the two substrates. In this manner, touchscreens can be made in an inexpensive, high-volume manner, then applied to any number of devices.

[0004] A second touchscreen style utilizes capacitance to identify touch location. The capacitive style requires only one conductive layer, which is typically arranged as the outermost layer of the device. Like in the resistive system, capacitive touchscreens can also be manufactured off-line, to be integrated later into the device. Capacitive touchscreens are advantageous because there is only one substrate, no spacers are required, and the optical transmissivity can be as much as 90%. Capacitive sensors are limited in that they require a conductive stylus, and the exposed conductive layer can be damaged during use. Protective outer coating materials do exist, but are very limited.

[0005] The final two popular methods for making a touchscreen, ultrasonic and infrared (IR) sensing, are very similar. Both styles use signal generators and receivers placed around the perimeter of the display. In the ultrasonic format, sonic waves are generated. In the IR format, infrared light beams are generated. In both, an array of beams or waves cover the surface of the display, and the sensors identify a touch location based on which beams are broken or what waves are bounced back. These systems cannot be integral to the display, and tend to be separate components of a larger assembly. Their major advantage is that they do not require a conductive stylus and have no optical loss. However, given the large number of generators and sensors required, they are the most expensive of the options, and can be very sensitive to surface flatness. These issues make such touchscreens infeasible for use with inexpensive, flexible displays.

[0006] Regardless of the style of sensing method used, touchscreen display assemblies can have significant problems. The first problem is that many types of displays are significantly pressure sensitive. If a surface of the display is deflected, it can cause a temporary optical imperfection, as is the case for typical liquid crystal displays (LCD), or permanent display failure, as is the case for many electrophoretic materials. In the LCD example, the optical characteristics and drive voltage of the display material is dependant on the thickness and planarity of the layer. If the display is deformed, then the thickness can change, causing an optical defect. In electrophoretic systems, the damage can be permanent. For example, pressure on the display layer can lead to seizure of rotating elements due to matrix distortion, or rupture of electrophoretic cell seals due to delamination.

[0007] The second problem with traditional touchscreen-in-front assemblies is the significant potential optical losses in the display due to the presence of the touch-sensing layer. This is not an issue for IR or ultrasonic styles of touchscreens, but it can be a significant issue when resistive or capacitive styles are utilized. This is unfortunate, as they are much preferred from a system cost perspective. Placing a touchscreen in front of a display can lead to 10% to 25% of loss in brightness and contrast, due to the maximum transmissivity of the screens.

[0008] In U.S. Pat. No. 4,789,858, Fergason and McLaughlin addressed the pressure sensitivity issue by encapsulating an LC material into a large number of discrete capsules. This structure held the LC material in its original thickness, regardless of layer deflection due to touch inputs. With this structure, the user could put significant pressure on the display layer, and even if the entire layer shifted, the capsules would keep the LC from migrating out, limiting optical defects. Although Fergason and McLaughlin addressed the first problem plaguing traditional touchscreen displays, they stayed with the touchscreen-in-front arrangement, and therefore did not address the second.

[0009] Others have tried to address the optical loss issue by rearranging the typical position of the touchscreen and display, relative to the user. Typically, flexible touchscreens are placed in front of a rigid display. This allows the touchscreen to flex, sensing the input, while the display remains mostly unaffected. However, if the display can be made to flex, then the order of assembly can be reversed. This places the touchscreen behind the display, eliminating the optical loss between the viewer and the image. However, this rearrangement of the structure places even more importance on the pressure sensitivity of the display. Where before the displays had the potential to see some deformation due to pressure, with this reversed structure, deformation of the display is actually required.

[0010] In U.S. Pat. No. 5,907,375, Nishikawa et. al. attempted to address the pressure sensitivity of LC displays in a touchscreen-in-back assembly by adding at least a shock-absorbing layer, and sometimes also a reinforcing plate, to the display assembly. These layers dissipated any touch input, in an effort to reduce the angle of distortion applied to the LC layer. This approach may be effective in reducing damage to the LC layer, but it does add at least one